

California Global Warming Solutions Act of 2006

## Cement Plant GHG Emissions Reporting Guidance

California Air Resources Board  
December 5, 2008

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## Agenda

- Introduction and Overview
  - Process and implementation
- General Reporting Requirements
  - Preparing for reporting
- Detailed Cement Plant Requirements and Examples
- Questions

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## Participation Information

- Workshop materials:  
<http://www.arb.ca.gov/cc/reporting/ghg-rep/ghg-rep.htm>
- Regulation and Staff Report  
(includes Regulation and other materials):  
<http://www.arb.ca.gov/regact/2007/GHG2007/GHG2007.htm>
- Webinar and Dial-In Information
  - <https://www2.gotomeeting.com/register/797641468>
  - Phone Dial-In: 888-677-4199  
Access Code: 49578

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## Mandatory Reporting Rulemaking Process

- Regulation approved by Board  
December 2007
- Modifications released for comment
- Final Statement of Reasons (FSOR)  
completed October 2008
- OAL approval December 2, 2008

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## Coordination with Future Regulations

- ARB Scoping Plan
- U.S. EPA Mandatory Reporting
- WCI Regional Reporting

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## ARB's GHG Reporting Tool

- ARB providing web-based platform for GHG reporting
  - Available January 2009
- Reporting tool demonstration workshop
  - December 19, 2008, 9:30 – 12:30

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## ARB Instructional Guidance for Reporting

- Instructional guidance document available at:  
<http://www.arb.ca.gov/cc/reporting/ghg-rep/ghg-rep.htm>
- Provides explanatory detail and examples, suggested best practices
- Not a substitute for the regulation

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## Review of General GHG Reporting Requirements

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## Who's Responsible for Reporting?

- At facilities, the entity with operational control
- For electricity transactions, a retail provider, marketer, or facility operator

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## What Sources Are Reported

- Stationary combustion
- Process and fugitive emissions when specified
- Mobile emissions optional

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## Exempt from Reporting

- Primary and secondary schools
- Hospitals
- Nuclear, hydroelectric, wind and solar power plant (except hybrids)
- Portable equipment
- Backup or emergency generators (permitted by air districts)

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## What Gases Are Reported

- CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O
- CO<sub>2</sub> from biomass fuels tracked separately
- HFCs, SF<sub>6</sub>, PFCs where specified

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## Preparing for 2009 Reports

- Must report 2008 emissions in 2009
- 2009 reports should be complete
- Emissions calculations may be based on best available data and methods
  - Regulation methods preferred
- Verification is optional for 2009 emissions reports

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## Reporting Schedules

- Power and cogen plants within larger facilities/entities are on the larger facility/entity schedule
- Other power and cogen plants and most general combustion facilities report by April 1
- Other facilities (including oil & gas) and entities report by June 1

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## Preparing for 2010 Reports

- 2010 emissions data report must meet full requirements of the regulation
- Monitoring equipment should be in place by January 1, 2009
- Everyone must verify their 2009 emissions data reports in 2010

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## Fuel Analytical Data Capture

- Data collected to support calculations of GHG combustion emissions
  - Mass, volume, flow rate, heat content, carbon content
- Need 80% capture rate for source verification
- For <20% missing data:
  - Use 40 CFR Part 75/60 if applicable
  - Use mean of data captured if not

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## Fuel Use Measurement Accuracy

- Measurement procedures must assure fuel use is quantified within  $\pm 5\%$  accuracy
- Maintain and calibrate devices to achieve  $\pm 5\%$  accuracy
- Quarterly calibrations of operators' solid fuel scales
- Keep records for verification

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## Using CEMS

- CEMS may be used to calculate combustion and process CO<sub>2</sub> emissions in most cases
- Operators may install new CEMS prior to January 2011
  - Meet 40 CFR Part 75 requirements
- Operators must choose between CEMS and fuel-based options for consistent reporting

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## Interim Data Collection Procedure

- ARB Executive Officer can approve interim procedure if fuel monitoring equipment breaks down
- When breakdown will result in  $>20\%$  data loss for report year
- Limitations and procedure in section 95103

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## Reporting *de minimis* Emissions

- Sources  $\leq 3\%$  of facility emissions, not to exceed 20,000 MT CO<sub>2</sub>e
- Emissions still reported, but may be estimated using alternative methods

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## Data Completeness, Record Keeping

- Retain documents on GHG inventory design, development and maintenance for five years
- Implement internal audit and QA for reporting program
- Log changes in accounting methods, instrumentation
- Specifications in sections 95104-95105

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## Verification: Key Steps

- Reporter contacts ARB-accredited verification body (VB)
- VB submits COI assessment to ARB
- Verification conducted following ARB OK
- Verification results discussed with reporter
- Reporter may revise report if time permits
- Verification body submits verification opinion to ARB and reporter

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## Third Party Verification

- Optional for 2009 emissions reports
- Required beginning in 2010
- Verification opinion due 6 months after report submittal

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## Verification Oversight

- ARB will provide training and accredit verifiers and verification bodies in 2009
- Verification process will assist compliance efforts and assure quality data
- Targeted review of submitted data and verifiers
- ARB responsible for enforcing regulation

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## Comments on general reporting requirements?



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## Cement Plant Reporting



- First reports due by June 1, 2009, reporting on 2008 emissions
  - Verification optional
- May use “best available” data, for 2009
  - But reports must include all sources specified in reg.
- All 2010 reports must meet full requirements of regulation
  - Begin collecting fuel activity data by January 1, 2009
- Report emissions for cement plant sources and gases by fuel type
  - Plus fuel use, efficiency metrics, clinker composition, feedstock composition, other information

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## Mandatory GHG Emissions Reporting

### Cement Plants

GHG Reporting Regulation  
§95111

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## Cement Plant Verification: 2010

- First verification opinion due by December 1, 2010 (on 2010 report)
  - Optional for 2009, but suggested
- Re-Verification of reports triennially
  - Exceptions:
    - Annual verification if large electricity generation or cogeneration operations are on site and under cement facility operational control
    - Verification update required if modifications to facility requiring change in air district permit<sup>28</sup>

## What to Report

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- Fuel use, by fuel type for facility
  - Provide fuel use by individual process units where separately metered
- GHG combustion emissions by type (i.e., CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O)
  - Emissions subdivided for each fuel used
- Process CO<sub>2</sub> Emissions
  - Produced by chemical reactions of feed stocks during pyroprocessing to produce clinker

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## Stationary Combustion GHG Emissions

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## What to Report (continued)

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- Process, feedstock, and production data
  - Clinker produced, lime and magnesium oxide content of clinker, cement kiln dust discarded, etc.
- Emissions from on-site electricity generation or cogeneration units
- Indirect energy use (electricity, heat, cooling)
- Efficiency Metrics
  - CO<sub>2</sub>/tonne cementitious product and CO<sub>2</sub>/tonne clinker

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## Estimating Fuel Consumption for Complete Facility

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- Report all fuel consumed (by type) for stationary combustion sources
  - Mobile or portable equipment excluded
- May use fuel purchase records or on-site fuel meters
- May use “stock method” for fuels stored on site:
  - Annual Use = (Purchases – Sales) + (Initial Stock – Final stock)

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## Estimating Fuel Consumption by Process Unit

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- Report kiln and non-kiln fuel use separately
- If separately metered, also report fuel use separately for each unit or group of units
  - Individual units could include boilers, driers, heaters, cogen systems, etc.
- Sum of unit-based fuel use may not equal facility-wide fuel totals

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## Combustion Source Emission Estimation Options

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- Use Continuous Emissions Monitoring Systems (CEMS) meeting specifications (§95125(g))
- Use Fuel-Based methods
  - Measure fuel parameters such as high heating value, carbon content, or both
  - Use to compute emissions using supplied equations and methods
- Source testing for specific fuels and gases

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## Reporting Fuel Use

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- Units for reporting
  - Million standard cubic feet for gases
  - Gallons for liquids
  - Short tons for non-biomass solids
  - Bone dry short tons for biomass-derived solid fuels
- See Appendix A of regulation for conversion factors

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## Source Testing for GHGs

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- Regulation provides specific source test options
  - CH<sub>4</sub> and N<sub>2</sub>O combustion emissions (§95125(b)(4))
  - CO<sub>2</sub> from the combustion of biomass solid fuels, waste-derived fuels, or municipal solid waste (§95125 (h)(3))
  - CO<sub>2</sub> from geothermal generating facilities (§95111(i)(2))
  - Sulfur recovery process emissions at refineries (§95113(b)(5)(B))

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## Special CEMS Requirements

- See section 95125(g) of regulation
- When co-firing fuels, may have to perform testing to identify fossil fuel and non-fossil fuel emissions
- Do not have to separately report process emissions or emissions by fuel type if only fossil fuels used
  - Fuel use by fuel type must still be reported

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## Example: Stationary CO<sub>2</sub> Emissions from Coal Combustion

- For coal combustion, carbon content of fuel must be measured (95110(d)(2))
  - Each fuel type has unique analysis, measurement and sampling requirements
- Measure monthly composite carbon content of weekly sub-samples (95125(d)(1))
  - Measurement frequency varies by fuel type
- Compute monthly emissions and sum to annual emissions

### **Example: Coal Combustion CO<sub>2</sub> Emissions**

CO<sub>2</sub> emissions (month 1, tonnes) = 5,000 tonnes coal (month1) x  
0.95 tonne carbon/tonne coal x 3.664 tonne CO<sub>2</sub>/tonne carbon

CO<sub>2</sub> Emissions (month 1, tonnes) = 17,404 metric tonnes

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## Fuel-Based CO<sub>2</sub> Stationary Combustion Emission Estimates

- Each fuel type has distinct testing and sampling requirements
  - High Heat Value
  - Carbon Content
  - Heat and Carbon Content
  - Default Emission Factors
  - Source Testing
  - CEMS
- Computed emissions are specific characteristics of the fuel used at the plant
  - See §95110(d) or Guidance Document Table 7.4.2.2

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## CO<sub>2</sub> for Solid Fuels Using Carbon Content Measurement

- Section 95125 (d)(1) of regulation

$$CO_2 = \sum_{n=1}^{12} Fuel_n * CC_n * 3.664$$

Where:

CO<sub>2</sub> = carbon dioxide emissions, metric tonnes per year

Fuel<sub>n</sub> = mass of fuel combusted in month "n," metric tonnes

CC<sub>n</sub> = carbon content from fuel analysis for month "n," percent (e.g. 95% expressed as 0.95)

3.664 = conversion factor for carbon to CO<sub>2</sub>

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### Calculating CH<sub>4</sub> and N<sub>2</sub>O Combustion Emissions

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- Use default emission factors in Appendix A of the regulation (Table 6)
- Or perform source testing using ARB approved protocols
  - See Appendix B of guidance and §95125(b)(4) for requirements

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## Cement Plant CO<sub>2</sub> Process Emissions

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### Reporting Combustion Emissions

- Report CO<sub>2</sub> emissions separately for kiln and non-kiln sources
- Report CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O emissions separately for each fuel used
- Report biomass CO<sub>2</sub> combustion emissions separately
- Report fuel consumption for each fuel
- Report fuel parameters where measured (HHV, carbon)

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### Process Emissions

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- If CEMS not used, compute and report process emissions
- Input data for computing emissions
- Data shown is also reported to ARB

<i>Input Name</i>	<i>Units</i>
Clinker produced	metric tonnes/yr
CaO content of clinker	% annual average
MgO content of clinker	% annual average
Non-carbonate CaO	metric tonnes/yr
Non-carbonate MgO	metric tonnes/yr
Amount of discarded CKD not recycled to the kiln	metric tonnes/yr
Organic content of raw materials	% annual average

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## Clinker-Based CO<sub>2</sub> Emissions Equation

- Need to compute EF<sub>Cli</sub> and EF<sub>CKD</sub> as inputs to compute emissions (see next slides)

$$\text{CO}_2 \text{ Emissions (metric tonnes)} = [(\text{Cli}) * (\text{EF}_{\text{Cli}})] + [(\text{CKD}) * (\text{EF}_{\text{CKD}})]$$

Where:

Cli	=	Quantity of clinker produced, metric tonnes
EF <sub>Cli</sub>	=	Clinker emission factor, metric tonnes CO <sub>2</sub> /metric tonne clinker
CKD	=	Quantity CKD discarded, metric tonnes
EF <sub>CKD</sub>	=	CKD emission factor, metric tonnes CO <sub>2</sub> /metric tonne CKD

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## Non-Carbonate Feeds for Clinker Emission Factor

- Added as raw meal to the kiln
- Measured by thermo-gravimetric methods
- Non-carbonate CaO
  - Calcium silicates
  - Coal ash
    - Incineration residue
    - Dust collectors
  - Steel slag or fly ash
- Non-carbonate MgO

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## Compute Clinker Emission Factor

- Emission factor for amount of CO<sub>2</sub> produced per amount of clinker produced

$$\text{EF}_{\text{Cli}} = \frac{[(\text{CaO content} - \text{non-carbonate CaO}) * \text{Molecular ratio of CO}_2/\text{CaO}] + [(\text{MgO Content} - \text{non-carbonate MgO}) * \text{Molecular Ratio of CO}_2/\text{MgO}]}{\text{Quantity of clinker produced}}$$

Where:

CaO Content (by weight)	=	CaO content of Clinker (%)
Molecular Ratio of CO <sub>2</sub> /CaO	=	0.785
MgO Content (by weight)	=	MgO content of Clinker (%)
Molecular Ratio of CO <sub>2</sub> /MgO	=	1.092
Non-carbonate CaO (by weight)	=	Non-carbonate CaO fraction of Clinker (%)
Non-carbonate MgO (by weight)	=	Non-carbonate MgO fraction of Clinker (%)

## Compute CKD Emission Factor

- Emission factor for amount of CO<sub>2</sub> produced per amount of cement kiln dust (CKD) generated and not returned to kiln
- The CKD factor is derived using clinker emission factor (computed previously) and the degree of CKD calcination, represented by "d" in the equation below

$$\text{EF}_{\text{CKD}} = \frac{\text{EF}_{\text{Cli}} * d}{1 + \text{EF}_{\text{Cli}} * d}$$

Where:

EF <sub>CKD</sub>	=	CKD Emission Factor
EF <sub>Cli</sub>	=	Clinker Emission Factor
d	=	CKD Calcination Rate see equation →

$$d = \frac{\text{fCO}_2\text{CKD} * (1 - \text{fCO}_2\text{RM})}{1 - (\text{fCO}_2\text{CKD}) * \text{fCO}_2\text{RM}}$$

Where:

d	=	fraction of carbonate CO <sub>2</sub> released, or converted, in the CKD
fCO <sub>2</sub> CKD	=	weight fraction of carbonate CO <sub>2</sub> in the CKD
fCO <sub>2</sub> RM	=	weight fraction of carbonate CO <sub>2</sub> in the raw material

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## Computing Clinker Process Emissions

- Input clinker production, CKD waste, emission factors
- CO<sub>2</sub> Emissions (metric tonnes) = [(Cli) \* (EF<sub>Cli</sub>)] + [(CKD) \* (EF<sub>CKD</sub>)]

Input Name	Value	Units
Cli, Clinker produced	500	metric tonnes/yr
EF <sub>Cli</sub>	0.47	tonne CO <sub>2</sub> /tonne clinker
CKD, Cement kiln dust discarded	5.0	metric tonnes/yr
EF <sub>CKD</sub>	0.30	tonne CO <sub>2</sub> /tonne CKD

CO<sub>2</sub> Emissions  
 = [500 metric tonnes clinker/year \* 0.47 tonne CO<sub>2</sub>/tonne clinker]  
 + [5.0 metric tonnes CKD/year \* 0.30 tonnes CO<sub>2</sub>/tonne CKD]  
 = 233 tonnes CO<sub>2</sub> + 1.5 tonnes CO<sub>2</sub>  
 = 235 tonnes CO<sub>2</sub>/year

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## Overview Example: CO<sub>2</sub> Emissions Reporting Summary

- CO<sub>2</sub> Emissions by Category (tonnes/year)\*
  - Natural Gas 75,000
  - Coal Combustion 50,000
  - Wood Combustion 10,000
  - Process Emissions 115,000
- Facility CO<sub>2</sub> emissions (tonnes/year)\*
  - Fossil Fuel Combustion 125,000
  - Process Emissions 115,000
  - Biomass Emissions 10,000

\*Level of detail shown may not be required if CEMS used

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## Other Production Emissions

- See guidance document for complete examples and explanations
- Compute CO<sub>2</sub> process emissions from organics in raw materials
  - Assumed as 0.2% of material consumed
  - CO<sub>2</sub> = 0.2% x Material Consumed x 3.644
- Estimate fugitive methane emissions from coal storage (§95125(j))
  - Use supplied emission factors and measured coal consumption

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## Additional Reporting

- Electricity generation or cogeneration under control of cement plant
  - If facility has capacity of 1 MW or more and CO<sub>2</sub> from generation is 2,500 tonnes or more, report using detailed electricity and cogen regulation requirements
  - If thresholds not triggered, report emissions and fuel combustion as stationary combustion sources for plant
- Report indirect energy usage
  - Electricity, heat, cooling (kWh or Btu)
  - Emissions not required

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## Efficiency Metrics

- Cement plants must report efficiency metrics
- Relates emissions to production variable
- Clinker and cementitious product efficiency metrics
  - Clinker efficiency metric equation

$$\frac{\text{CO}_2 \text{ emissions (tonnes)}}{\text{Metric tonne clinker}} = \frac{\text{Direct CO}_2 \text{ emissions from cement manufacturing (tonnes)}}{(\text{Own clinker consumed or added to stock}) + (\text{own clinker sold directly})}$$

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## Summary of Data Reporting

- ARB reporting tool will help to guide reporting process and track data inputs
- Some input data will be on hand through normal business practices
  - Fuel use, clinker produced, feedstock composition, etc.
- Other data will need to be collected
  - Fuel heat content, source test data (optional)
- Tool will allow reporting and tagging of additional data reported voluntarily

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## Cement Plant Data Management and Reporting

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## Data Requirement Summaries

- For setting up facility data reporting and tracking systems, the following tables may be helpful
- These tables are provided as a convenience only
- They do not add to, substitute for, or amend the regulatory requirements the regulation [Subchapter 10, Article 2, sections 95100 to 95133, title 17, California Code of Regulations]
- It is the responsibility of the operator to ensure complete reporting

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### Data Requirements Summary (Part 1)

Field Name	Units	Notes
<b>Facility Level Totals</b>		
Total CO <sub>2</sub> Emissions	metric tonnes	Includes combustion & process
Total N <sub>2</sub> O Emissions	metric tonnes	
Total CH <sub>4</sub> emissions	metric tonnes	
<b>Stationary Combustion Emissions</b>		
Fuel Type	name	Report for each fuel
Fuel consumed annually	scf, gal, tons	Report for each fuel
Emissions by Fuel Type	metric tonnes	CO <sub>2</sub> , CH <sub>4</sub> , and N <sub>2</sub> O by fuel type
Annual Average Carbon Content (if measured)	facility specific	By fuel type for fuels measured
Annual Average Heat Content (if measured)	facility specific	By fuel type for fuels measured
Facility specific emission factors (if applicable)	kg CO <sub>2</sub> , CH <sub>4</sub> , N <sub>2</sub> O /fuel unit	By fuel type when used. One or multiple GHGs may be included
CEMS if applicable	metric tonnes	
Total Stationary Combustion Emissions	metric tonnes	Sum of CO <sub>2</sub> , CH <sub>4</sub> , and N <sub>2</sub> O combustion emissions (no process emissions)

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### Data Requirements Summary (Part 3)

Field Name	Units	Notes
<b>Fugitive Emissions</b>		
Coal Type	name	
Total Tons of Coal Purchased	tons	
Emission Factor	scf CH <sub>4</sub> /metric ton	multiple types
Total Fugitive Emissions of CH <sub>4</sub>	metric tons	
<b>Efficiency Metrics</b>		
Amount of own clinker consumed	metric tons	
Amount of clinker added to stock	metric tons	
Amount of clinker sold directly	metric tons	
Type of clinker substitutes consumed for blending	name	multiple types
Amount of clinker substitutes consumed for blending	metric tons	
Type of cement substitute consumed for blending	name	multiple types
Amount of cement substitute consumed for blending	metric tons	
Efficiency Metric (clinker)	CO <sub>2</sub> tonnes/tonne	
Efficiency Metric (clinker + substitutes)	CO <sub>2</sub> tonnes/tonne	

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### Data Requirements Summary (Part 2)

Field Name	Units	Notes
<b>Direct Process Emissions</b>		
<i>Clinker Based Methodology for CO<sub>2</sub> Emissions</i>		
Clinker Emission Factor	kg CO <sub>2</sub> /metric tonnes clinker	
Quantity of Clinker Produced	metric tonnes	
CaO Content of Clinker	%	
MgO Content of Clinker	%	
Non-Carbonate CaO	%	
Non-Carbonate MgO	%	
CKD Emission Factor	kg CO <sub>2</sub> /metric tonnes CKD	Applies to cement plants that discard CKD.
Plant-specific CKD Calcination Rate	unitless	
Quantity of CKD Discarded	metric tonnes	
CO <sub>2</sub> Emissions from Clinker Production	metric tonnes	
<b>TOC Content in Organic Materials</b>		
Amount of Raw Material Consumed	metric tons	
Organic Carbon Content of Raw Material	%	
CO <sub>2</sub> Emissions from TOC in Raw Materials	metric tons	
Total Direct Process Emissions	metric tons	

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### Data Requirements Summary (Part 4)

Field Name	Units	Notes
<b>Indirect Energy Use</b>		
Annual Electricity Purchases	kWh	
Electricity Provider	name	
Annual Energy Purchase (steam)	BTUs	
Energy Provider	name	
<b>Electricity Generation</b>		
Use electricity generation reporting requirements		See regulation and guidance for requirements
<b>Cogeneration</b>		
Use cogeneration reporting requirements		See regulation and guidance for requirements.

\* Note: These tables are provided for information only. If any conflict is found between this table and the regulation, the regulation always takes precedence.

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## What Can You Do Now?

- Become familiar with regulation
  - §95103, 95104, 95110, 95125
- Read appropriate guidance document chapters <http://www.arb.ca.gov/cc/reporting/ghg-rep/ghg-rep.htm>
- Set up systems for tracking fuel use and other parameters in 2009
- Participate in reporting tool demo (12/18/2008)
- Begin preparing 2008 emissions report <sup>61</sup>

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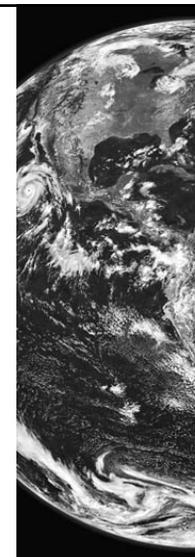
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GHG Mandatory Reporting Website  
<http://www.arb.ca.gov/cc/reporting/ghg-rep/ghg-rep.htm>



Thanks for  
participating

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